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Pulling color from a colored image for coloring gray images using CSO algorithm

Abstract. Pictures have a wide range of information, and the most important characteristic of pictures is colors, where colors have great importance by which gray images can be colored in order to obtain greater qualities for distinguishing pictures. The presence of old historical images in their gray colors was the motive for doing this research for the purpose of coloring them. Three algorithms were used to color digital images, which are the methods of brightness, medium, and lightness. A color digital image was approved to be used as a color palette to color the grayscale image. This was done by taking the color from the color image after replacing it with a grayscale, and matching the pixel locations with the locations of the grayscale image. The approximate color is placed in the grayscale image if it matches, otherwise control points (C1, C2) for the purpose of utilization. It was concluded that the luminosity method is better than the average and luminance methods based on the MSE and PSNR measures, and the Visual Basic language was used to complete this research.

*Streszczenie. Obrazy zawierają szeroki zakres informacji, a najważniejszą cechą obrazów są kolory, przy czym kolory mają ogromne znaczenie, dzięki czemu można pokolorować szare obrazy w celu uzyskania lepszych cech odróżniających obrazy. Motywem podjęcia badań w celu ich pokolorowania była obecność starych obrazów historycznych w ich szarej kolorystyce. Do kolorowania obrazów cyfrowych zastosowano trzy algorytmy, którymi są metoda jasności, średniej i jasności. Zatwierdzono kolorowy obraz cyfrowy do użycia jako paleta kolorów do pokolorowania obrazu w skali szarości. Dokonano tego poprzez pobranie koloru z obrazu kolorowego po zastąpieniu go skalą szarości i dopasowanie lokalizacji pikseli do lokalizacji obrazu w skali szarości. Przybliżony kolor jest umieszczany na obrazie w skali szarości, jeśli pasuje, w przeciwnym razie punkty kontrolne (C1, C2) w celu wykorzystania. Stwierdzono, że metoda luminancji jest lepsza od metody średniej i luminancji opartej na miarach MSE i PSNR, a do realizacji badań wykorzystano język Visual Basic. (**Wyciąganie koloru z kolorowego obrazu w celu pokolorowania szarych obrazów za pomocą algorytmu CSO**)*

1. Introduction

How can imagine our world without colors! What if the whole world was gray, so how can we infer that the stuff, and how the intervention of joy to our hearts without colors? All this and more is to try coloring all form images of gray .

Image processing expanded, and its applications covered various life activities, and became familiar with the principles of image processing and an urgent need, as images take a wide range of information, and the most important personality characteristic of an image is color, as colors are of great importance that can be added to grayscale images in order to increase the clarity of features in Pictures When the goal is to present a true picture of the world, such as in television or still photography.[21]

The most commonly used coloring methods are with color printers, color screens, etc., and can be used with applications, where coloring is the desired goal of most of these applications, such as coloring animations, films, and others [8,9].

When the digital image processed, RGB system is used in colored screens and as a fundamental colored system on television, scanners, and widely used in digital cameras, the intensity in this system is 3 bytes and allows to store more than 16 million colors. Where CMY and CMYK systems are used in printers, and the color intensity in this system are 4 bytes and allows to store more than 4000 million colors, there are other systems used in various types of hardware [18].

Research objectives is to choose an grayscale image and convert it into a colored image using three types of algorithms to form the (Code book) from the colored image (the plotter) to get a new colored image closed in the colors to the real image, and making a comparison between three methods to extract the best way in coloring.

2. Literature Review

Mrs. Smriti Kumar and Mr. Ayush Swarnkar, introduce a simple process of colorizing a grayscale image, using a color image similar to a grayscale image. Where he converted both images into a color space associated with the decoration YCbCr, and then divided these images into small windows of equal size, the mean and standard deviation of the data points were calculated based on the luminance values in each of these windows to calculate the scaling of the texts, and also texture features such as energy were extracted and entropy, variance, correlation, and homogeneity based on the correlation matrix for each of these windows. The researcher applied appropriate weights to the texture features to calculate the texture similarity scale and then calculated the similarity scale based on the texture similarity scale for each of these windows in both images.

Each window in a gray scale image was compared with another window in a color image using this similarity scale and the best matching window was found. Then the tonal characteristics of the color window are transferred to the pixels of the gray window and the colorization of the gray scale image is achieved. [17,19,20].

Rohini Sharma and Ekta Walia, presented the results of the performance analysis of non-adaptive and adaptive edge-based LSB masking for color images. These algorithms were modified to implement color images and compared on the basis of different evaluation parameters such as peak signal noise ratio (PSNR) and mean squared error (MSE).. [4,5,6,10,22,23]

Baaj, R. M., and Allbun, J., and Rbdawi, G., the number of colors of the carpet image taken by the scanner has been reduced, to obtain an image that contains five colors that are actually present in the source image, after it became composed of 16 million colors as a result of using the scanner, taking care not to distort the resulting image so that you get all shapes into the original image automatically without user interaction [3].

Nidhal K. EL Abbadi1 , Eman Saleem2, provide an automated way to colorize grayscale images based on the Lab color space and reference image. In this method, the grayscale values of the image were normalized according to the Lightness of Lab model of the color image. The

proposed method gives good results (visually **3.1**and determine PSNR), and we also get good results when compared to other works. The goal of this method is the need for a reference image that contains the same content in the grayscale image with a similar color histogram,**3.2**nd choosing the reference image with the same categories as in the grayscale image gives great results in the colorization process [11, 12, 25].

Nidhal K. EL Abbadi1, Eman Saleem2, Introduce a method for colorizing grayscale images based on the SVD algorithm and Lab color space. The coloring process will give better results when selecting the reference image **3.3**with colors that are more suitable for coloring the grayscale image and also when the reference image has the same category. It was proved that the size of the cluster has no effect on the coloring process. The color image should be visually closer to the ground reality image, the work proved that the use of SVD transform is very useful for selecting the best pixel information from the reference image for the specific pixel coloration in gary's image, we concluded that colorization using the Lab color space is more effective for improving coloration quality. [7,16]

Shaodi You, Nick Barnes, Janine Walker, Suggest a way to convert color images to gray scale while keeping brightness as consistent as possible. The main ideas of brightness consistency are to maintain the feel and naturalness of the original color, and to maintain color contrast. Using these 16 key ideas from Shaodi You Nick Barnes, quantitative measures were derived based on recent studies in the science of vision. An optimization framework 1 is proposed to find the grayscale image that improves the proposed brightness consistency measure. To evaluate the proposed methods, we used the existing datasets and the proposed new dataset. We also validated both the algorithm and the measurement with a user study. [13].

Amer, R., Talal, Z., Hafez, N., Ghanim, A., a digital image is tested in color cast using an algorithm based on statistical operations such as contrast, and average equivalent circuit and then removed the tyrant color after previewing the results obtained from the use of an algorithm [2].

Reddy R. K., Raju K. P., Kumar L. R., Kumar M. J., A method for converting a gray scale image to color using the YCbCr color space technique is presented. How to use this method to convert gray scale to color image is shown [15].

Zade Sh., Tidke S., A very simple algorithm was used that uses a color space associated with the ornamentation and then applies a simple process to it. A color space with decoration axes is a useful tool for manipulating color images in this work. Colorization of the gray scale image is achieved by matching the luminance values to the data points, thus obtaining believable output images given an appropriate input image. Feature extraction was done using the PSO algorithm, based on correlation matrix for the purpose of texture matching between two images [24].

3.   Coloring stages

In this research, a number of steps were followed for the purpose of extracting color from the color image and adding it to the gray image, and they are summarized as follows:
• Choose a grayscale image.
• Choose a color image (plotter).
• Extracting features using the CSO algorithm.
• Plotter processing to create a grayscale image using **3.4** several equations.
• Create the first and second codebooks.
• Colorize and view the resulting color image.

Gray image selection

In this step, the grayscale image to be colored will be selected.

Plotter image selection

In this step, a color image will be selected to rely on its colors in coloring the gray image. The process of selecting the colored image must be coordinated, as an image is selected that is close in details to the image to be colored in order to give the desired results in coloring.

Feature extraction using CSO algorithm

After reading the gray image, and the plotter image, the CSO algorithm is used to select their features factors.

Among the optimization algorithms used to find the important characteristics and characteristics of the image, the indicative optimization algorithms are the cats algorithm, which depends on the behavior of cats in nature. Cat behavior has been divided into two important and consistent parts, which are search and active behavior tracking. Through observation it was found that cats become more accurate in observing their surroundings, and eagerly anticipate the next step that the cats will take.

The cat swarm algorithm is one of the best optimization algorithms to find the best overall solution, but sometimes, in a number of cases, the cat algorithm takes time to find the right solution, and the goals of feature selection are to reduce the number of features and remove irrelevant, noisy, and redundant data, as shown in (figure-1) [1].
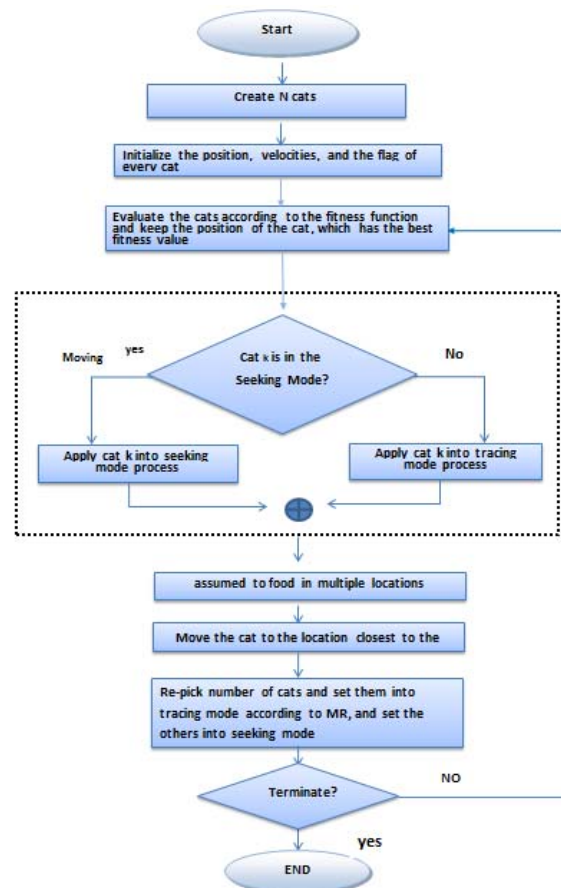

Fig. 1: feature extraction

The Plotter Processing

The color image, which will be used as a plotter, is converted to a grayscale image, while preserving the original values of the color, and then a comparison is made between

the gray values of the image to be colored with the gray values of the image of the painter [14].

Three different methods were taken to obtain the grey, for use in post-treatments:
- Luminosity method.
- Average method.
- Lightness method

3.4.1 Luminosity method

This method is based on the use of three consisting of red, green and blue pixels and multiplies these values by a specific and fixed value so that the final product of the multiplied values is equal to 1, after obtaining the gray value it is placed in the codebook, as shown in Equation 1: [14]

(1) $Gray = 0.21R + 0.71G + 0.07B$ 2-

3.4.2 Average method

In this method, three values consisting of red, green, and blue pixels were used, and these values were summed and divided by the number 3. The resulting gray value was stored in the codebook, as shown in Equation 2: [14]   4-

)2) $Gray = (R + G + B) / 3$ .....)

3.4.3 Lightness method

This method used equation (3), depending on the three values that consisting the pixel red, green and blue, the Max and Min values among the three values is calculated and summed them, then dividing the resulting value on 2, the result is the gray value where put in the Code book [9,14].

(3) ……… $Gray=(max(R,G,B)+min(R,G,B))/2$

4 Configuring Code Book

The first Code book consists of five fields as shown in table 1:
- The first field is the presence of gray color in the plotter image after conversion to gray using one of three ways (brightness, lighting, average methods).[3,9] .
- The second field represents the value of gray as well as it represents the location address which is used to access the color location in the code book.
- The remaining three fields represent the values of red, green and blue.

Table . 1 the first Code Book

Blue value	Green value	Red value	Gray value	Existence
87	57	77	86	1
				0
90	65	88	70	1
				0

The second Code Book consists of five fields too, taken from the first code book, as the following format:
- If the value of the first field (Existence) greater than zero, then the values of the five fields (Existence, gray value, red value, green value, blue value) were taken from the corresponding first Code book and puts in the second Code book.
- If the first value of the field (Existence) is equal to zero, then discard the corresponding fields in the Code book.

In other words, the second Code book contains the same values of the first code book in which the Existence filed is equal to 1 only. As in Table 2, finally the second Code book will be used and neglecting the first one.

Table 2. the second Code book

Blue value	Green value	Red value	Gray value	Existence
87	57	77	86	1
90	65	88	70	1

Coloring method and displaying colored image

At this stage, seeking for the gray value taken from the image to be colored in the field Existence from the second Code book:

If the value is found the same, take the value for three fields (red, green and blue) in the corresponding second Code book, and uses in coloring (toggle their values with the values of the image to be colored).

If the value of the gray smaller than the smallest value found in the Code book, the control points are placed, C1 and C2, so that C1 = 0 and C2 = 1.

If the gray value is greater than the largest value found in the Code book that named last, then make C1 = last-1 and become C2 = last.

However, if the value of the gray sandwiched between two values existed in the Code book, then C1 becomes equal to the index of the first value and C2 equal to the index of the second value.

After getting the gray value and C1, C2 values, apply equation (4) to extract the value of the variable k, which will be used in coloring (noting that this does not apply to the first point as it is to find points of painting directly from the Code book) [9].

(4) $K = (gray-C1\ gray) / (C2\ gray-C1\ gray)$ ....
where:
C1 gray: represents the gray color value in the top of the code book.
C2 gray: represents the gray color value in the lowest of the code book.
Gray: represents the value that was obtained from the colored image after conversion to gray using one of the three equations (brightness, average and lighting) mentioned above.

Finally, the value of variable k is used for getting the primary colors in any image (red, green and blue), as follows:
Red = C1_R + k * (C2_R - C1_R)
Green = C1_G + k * (C2_G - C1_G)
Blue = C1_B + k * (C2_B - C1_B)
where:
C1_R: represents the red color value of the top location in the code book.
C1_G: represents the green color value of the top location in the code book.
C1_B: represents the blue color value of the top location in the code book.
C2_R: represents the red color value of the lower location in the code book.
C2_G: represents the green color value of the lower location in the code book.
C2_B: represents the blue color value of the lower location in the code book.
The resulting colored image is shown on the screen after replacing the values of the resulting image with the gray image to obtain the values of color image.

5 Coloring image flowcharts

In this stage, clarifying the general stages which used for coloring images, as shown in figure (2).

5.1 Average method flowchart

In this scheme will show the steps of average method, as shown in figure (3).

5.2 Lightness method flowchart

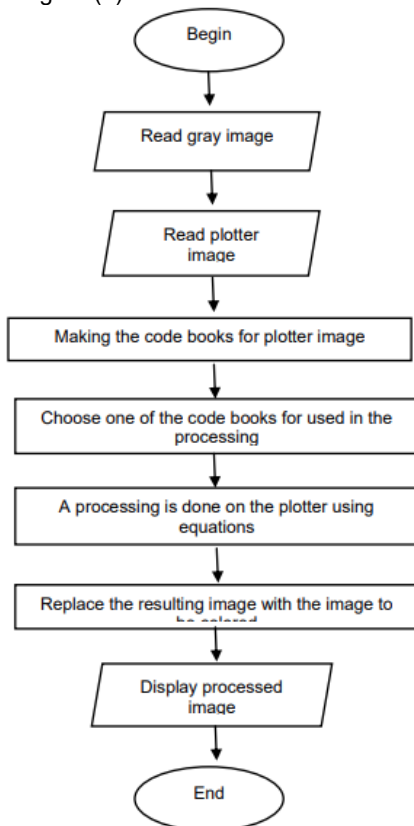In this scheme will show the steps of lightness method, as shown in figure (4).
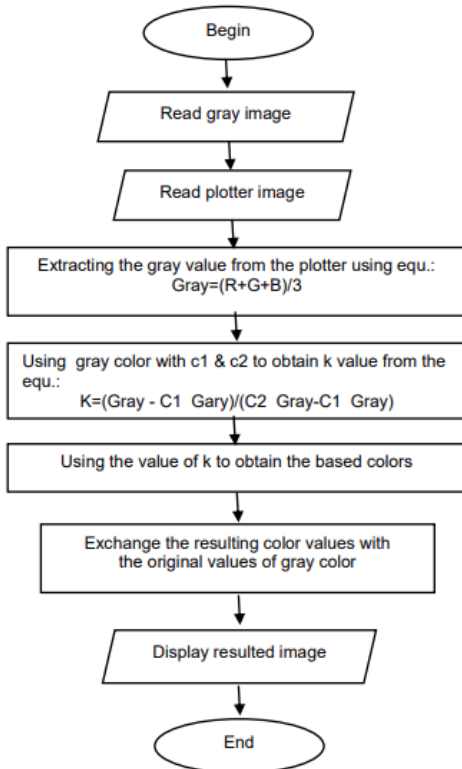

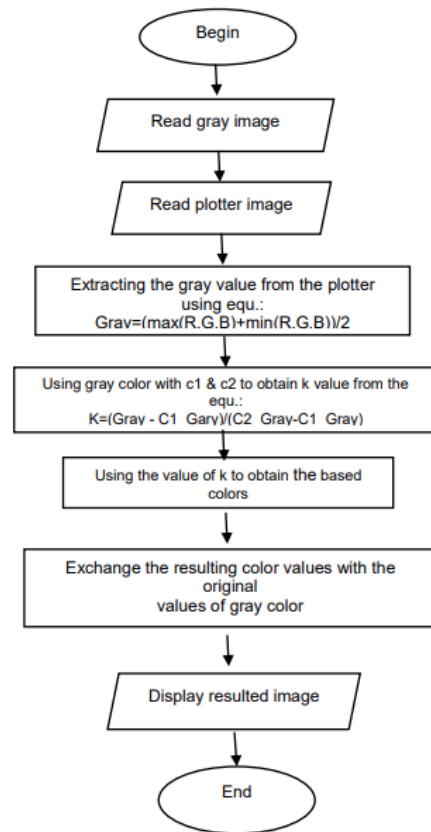Fig. 2 Coloring image flowchart

Fig. 3 Average flowchart

Fig. 4. Lightness flowchart

5.3 Luminosity method flowchart

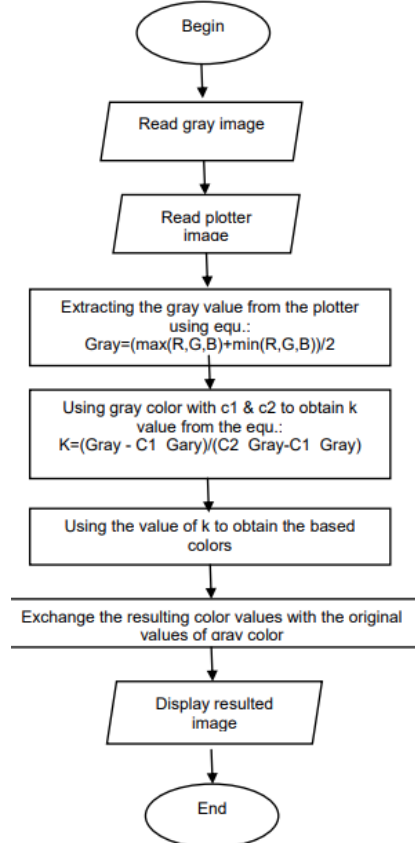In this scheme will show the steps of luminosity method, as shown in figure (5).

Fig. 5 Luminosity flowchart

6 Interfaces

In order to understand the working mechanism and to know the results of the three algorithms used in the research, the quick display interfaces were used using Visual Basic, and after displaying the main interface, the gray image to be colored is chosen, and a colored image is selected to be a plotter by pressing the browse button, as shown figure (6):

Fig. 6   interface

7   Discusion and Comparative results

Through the application of the three ways and observe the results, reached:

1.   When Luminosity method applied, which have the best performance, where the results was good in clarifying the gray image, that is depend on the method of weight (multiplying R, G and B in a particular value, which is not lead to similar results , this explains the clear appearance of the image.

2.   Lightness method did not give the desired results, just because of the similarity values Min and the Max for different two gray colors which led to the same value.

3.   The averaging method failed to choose the appropriate color for the image and the results were weak, because averaging the three colors red, green and blue always leads to moving to the same location in the code and thus the same color is reserved for more than one different gray point, and thus this method is less efficient than the other two methods.

4.   The plotter image must be chosen closer to the image to be colored, to increase the efficiency of the coloring and the undesirable colors were canceled, for example, if the image to be colored is the landscape, then must choose an image with appropriate colors to the landscape for obtaining good colors to the resulting image.

5.   The plotter image must selected un complex to avoid the distortion in the image, this due to the fact that the gray gradients ranging from 0-255 and may coincide the existence of two different colors having the same value in the Code book.

6.   The three algorithms did not give satisfactory results for coloring personal photographs, where they found some distortion in the face, as it requires a special kind of treatment, also the plotter image must contain the face only, without any further details.

7.   MSE equation for Euclidian distance is used to find the distinction between two pixels for images before and after processing, also PSNR measure is found:

$$MSE = \frac{1}{m\,n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

The PSNR (in dB) is defined as:

$$PSNR = 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$
$$= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right)$$
$$= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE)$$

Where: I is original image.

K is the colored image resulted from one of three methods.

m*n image size.

Using MSE, table (3) shows that the luminosity method has the less numbers between the original image pixels and the processed image pixels.

Table 3.   Comparative results using MSE

Average method	Lightness method	Luminosity method	Colored image
20.7752	18.5087	16.4675	Img1
21.1098	19.6521	18.5430	Img2
14.8654	14.0329	13.5678	Img3
16.7890	15.5753	15.0168	Img4
21.5098	19.0762	17.7689	Img5
29.5298	28.9832	28.1943	Img6
30.9879	30.1963	29.0987	Img7
21.6578	20.0325	18.4632	Img8
23.8712	22.3768	21.8761	Img9
25.2178	23.9878	23.2093	Img10
19.9823	19.7650	17.2109	Img11

8.   From the results in Table (4) we conclude that the PSNR high value means, mean square error between the original image and reconstructed colored image is very low. It implies that it has been properly colored. In the other way, the colored image quality is better. And from the deferent between PSNR values of the three algorithms (Brightness(Luminosity) method, Lightness method, Average method) the Brightness method is the best.

Table (4) Comparative results using PSNR

Average method	Lightness method	Luminosity method	Colored image
13.4295	17.9503	47.3449	Img1
10.6051	15.515	24.7908	Img2
10.189	17.7068	42.4715	Img3
11.6734	19.7623	44.7658	Img4
16.4590	20.0984	38.6521	Img5
15.5576	21.5467	43.9567	Img6
14.7612	22.8769	39.6782	Img7
10.4752	18.9340	44.8761	Img8
11.9834	24.3121	47.2387	Img9
12.7084	16.7634	40.5724	Img10
10.6721	15.8709	44.7123	Img11
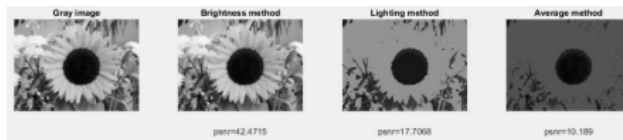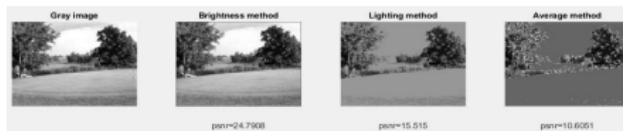
From the deferens between PSNR values of the three algorithms (Luminosity method, Lightness method and Average method) the Luminosity (Brightness) method is the best one.

Using Peak Signal-to-Noise Ratio (PSNR), the resulting images is as follows:

Gray image	Colored image	Luminosity method	Lighting method	Average method
		PSNR=20.91 dB	PSNR=13.07 dB	PSNR=9.82 dB
		PSNR=16.95 dB	PSNR=11.95 dB	PSNR=8.84 dB
		PSNR=20.92 dB	PSNR=15.82 dB	PSNR=13.12 dB
		PSNR=22.09 dB	PSNR=15.94 dB	PSNR=12.64 dB
		PSNR=23.50 dB	PSNR=17.08 dB	PSNR=15.78 dB

9 Conclusions and Recommendation

Based on the MSE and PSNR standards, it was found that the luminosity method gives good results and is better than the other two methods, luminance and average.

- Make some processes to get a good results for the personal image
- Coloring old videos.
- Using some intelligence techniques such as using Genetic algorithm, Swarm algorithms, etc., in the generation of plotter image.

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